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1-W continuous-wave diode-pumped Cr:LiSAF laser

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Abstract

Mode-matching a diode bar to a strongly asymmetric laser mode allows us to achieve relatively high average powers from laser materials with relatively poor thermal conductivity. We demonstrate a Cr:LiSAF laser with >1 W average output power.

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We demonstrate a diode-pumped Cr:LiSAF laser with an average output power of >1 W. This is the highest reported average output power from a Cr:LiSAF laser to our knowledge. Using a strongly asymmetric laser mode allows both optimized mode matching and efficient cooling of the laser crystal. The technique should also be extendible to other thermally-poor laser materials such as Nd:glass.

Cr:LiSAF's broad emission bandwidth supports both wavelength tunability and femtosecond pulse generation. We have previously demonstrated self-starting mode-locking of a diode-pumped Cr:LiSAF laser with pulse widths below 50 fs using an antiresonant Fabry-Perot saturable absorber [1], including wavelength tunability while mode-locking of 30 nm, and output powers in excess of 100 mW.

Motivated by the desire for higher average power, we recently demonstrated 400 mW average power [2], limited by the available diode lasers. Higher power pump diode bars have been demonstrated to produce up to 40 W [3] at 690 nm from a 1 cm wide bar. However, to pump

Cr:LiSAF with such a bar, we have to combine optimized mode-matching with an efficient cooling mechanism.

The laser setup is shown in Fig. 1. The diode-laser array emits >10W at 690 nm from a 1 cm wide bar mounted on a silicon micro channel cooling plate for heat removal [3]. The pump diode beam is imaged into the crystal to a diameter of approximately 2 mm x 120 μm, after aperturing about 25% of the beam for improved focusing. The diode is >1000 times diffraction limited in the tangential plane. In the sagittal plane, the diode beam is nearly diffraction limited (5X after the microlens). The pump-generated heat in the crystal is cooled mainly by a one-dimensional heat flow (Fig. 2). A crystal thickness of 1 mm between copper heatsinks held at 10°C also helps reduce the temperature rise in the crystal. Simulations based on the material parameters in Ref.[4] show that a thermal load of 10 W results in a temperature rise of several tens of degrees C, which causes negligible upperstate lifetime quenching and thermal lensing.

The lasing mode in the crystal has a diameter of 2 mm x 130 μm and is well mode-matched to the pump beam in both the tangential and the sagittal plane. We obtained a CW output power of 1.1 W at 5.5 W absorbed pump (Fig. 3) with a slope efficiency of 24% and no significant saturation at higher pump power. The output beam appeared TEM_{00} but had an M^2 of ≈1.4, probably due to the pump beam, which has somewhat higher intensity at the edges of the diode bar and therefore supports a slightly non-diffraction-limited laser mode. Further optimization should improve the M^2 value of the laser.

References:

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Figure Captions:

Figure 1: Laser setup of Cr:LiSAF laser pumped with a high-power diode-laser array. Mirror M1 is cylindrical with 20 cm radius of curvature in the sagittal plane and M2 is a spherical mirror with 20 cm radius of curvature.

Figure 2: Cross section view of Cr:LiSAF crystal (not to scale) as pumped by the strongly asymmetric diode beam (shaded area). Heat flow is mostly one-dimensional (arrows).

Figure 3: Cr:LiSAF laser output power as a function of absorbed pump power from the diode-laser array. Slope efficiency is 24% at an output coupling of 1%. The Cr:LiSAF heat sink was kept at a temperature of 10° C.

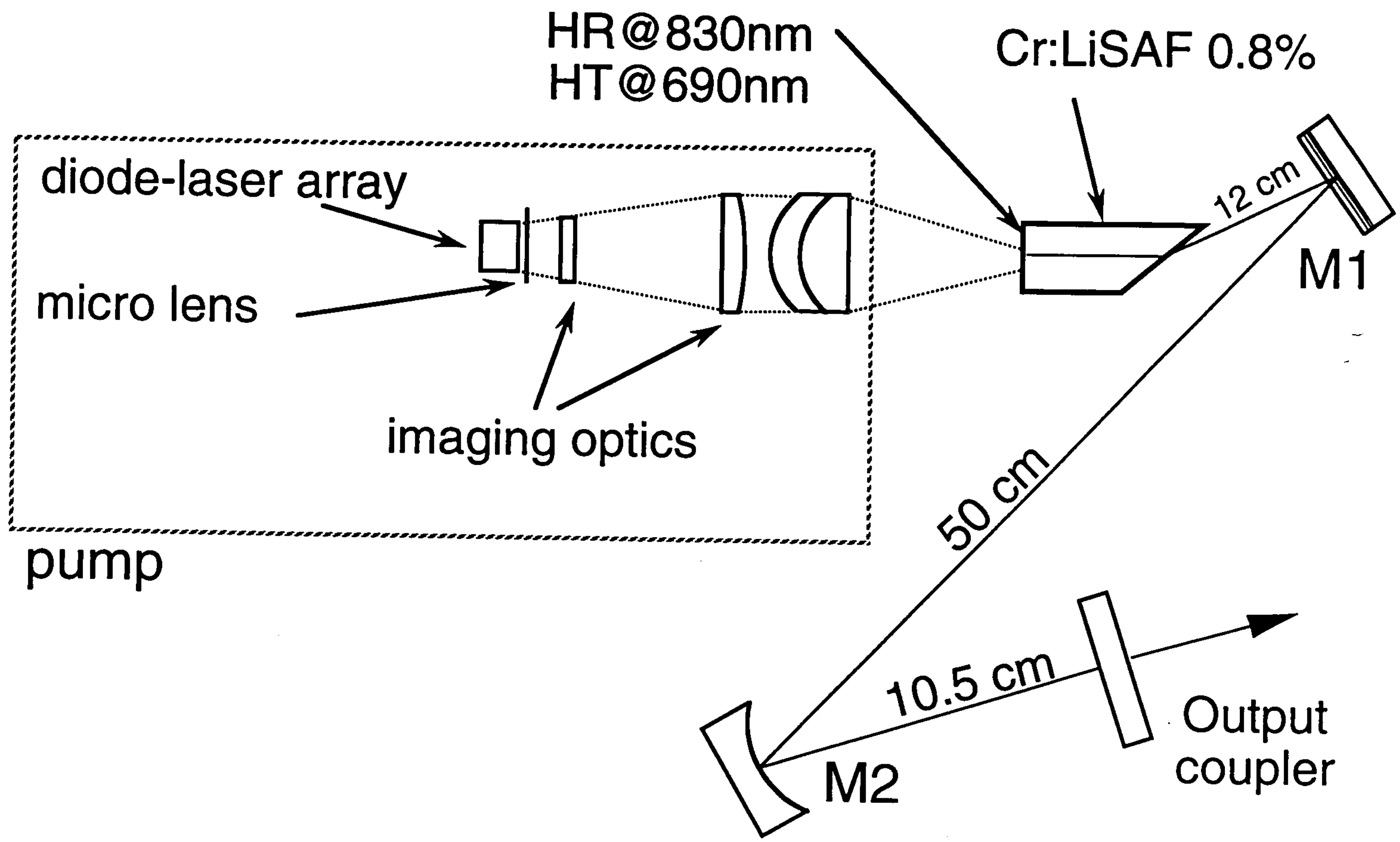

Figure 1

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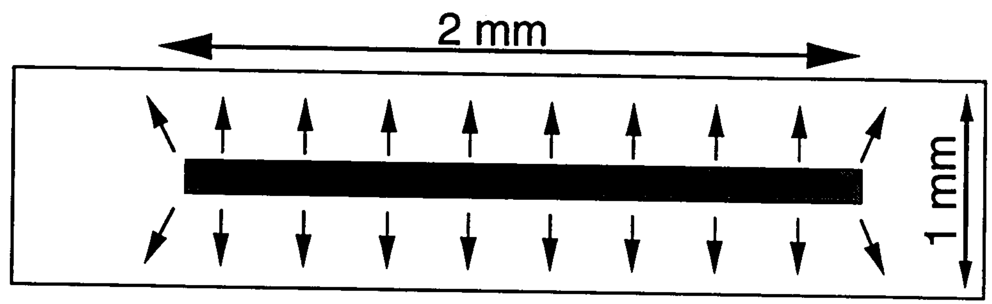

Figure 2

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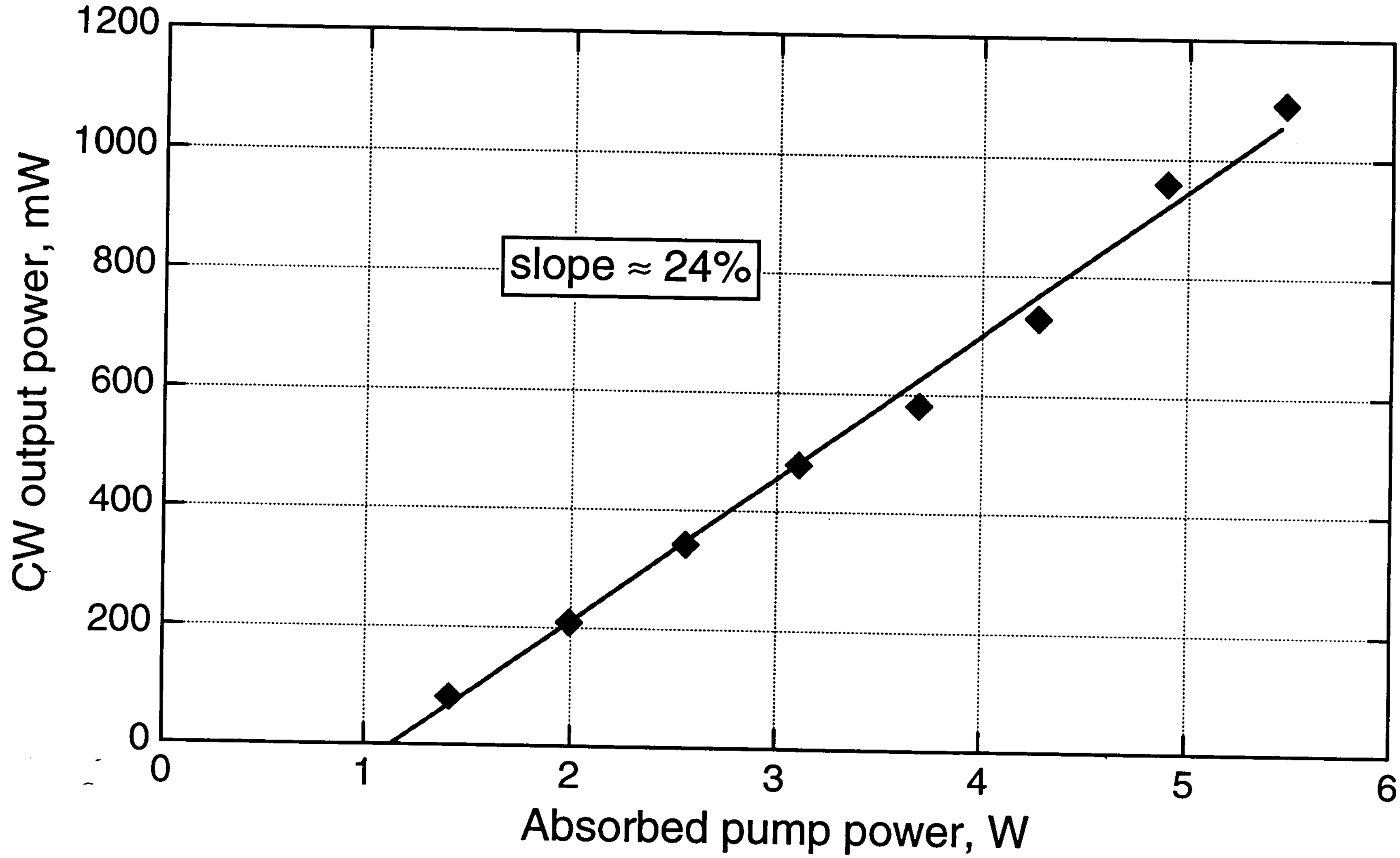

Fig. 3

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